Subsurface Monitoring and Verification at the Frio Pilot Test

Larry Myer[1], Sally Benson[1], David Cole[4], Tom Daley[1], Christine Doughty[1], Alan Dutton[2], Barry Freifeld[1], William Gunter[5], Mark Holtz[2], Susan Hovorka[2], Mike Hoversten[1], B. Mack Kennedy[1], Yousif Kharaka[6], Kevin Knauss[3], Paul Knox[2], Ernie Majer[1], Tommy Phelps[4], Karsten Pruess[1], John Robinson[5]

[1]Lawrence Berkeley National Laboratory, Berkeley CN
[2]Texas Bureau of Economic Geology, Austin TX
[3]Lawrence Livermore National Laboratory, Livermore CA
[4]Oak Ridge National Laboratory, Oak Ridge TN
[5]Alberta Research Council, Edmonton Canada
[6]U S Geological Survey, Menlo Park CA

Monitoring and verification is required to demonstrate that the movement and fate of injected CO_2 can be reliably predicted and evaluated. A multi-disciplinary multi-institutional team is carrying out geophysical, hydrologic, and geochemical measurements for monitoring and verification of the pilot CO_2 injection test in the brine saturated Frio formation in Texas. The pilot involves injection of about 3000 tons of CO_2 at a depth of about 1500m in one well and monitoring in a second well located about 30m away. Interpretation of 3-D surface seismic, coupled with petrophysical analyses and other geologic data, shows that the test site is located in a small fault block off the flank of a salt dome, and provides important baseline information for the monitoring measurements. The injection interval consists of alternating layers of sand and shale, with sand layer thickness on the order of 10 m, overlain by the 75 m thick Anahuac shale. Geophysical monitoring involves time-lapse measurements, incorporating both surface and borehole techniques. A suite of wire-line logs, including porosity, density, lithology, and velocities, provides rock property data in the near wellbore region of the new injection well drilled for the pilot. Repeated neutron logs provide data on saturations in the rock near the monitoring well as the CO_2 passes. Selection of geophysical techniques for monitoring the inter-well region was aided by modeling in which reservoir simulation was used to predict fluid distributions, which were then input to geophysical models to predict performance of candidate techniques. Crosswell seismic measurements provide information on the inter-well scale geologic features, and, in combination with appropriate rock physics models, quantitative information on CO_2 saturation between boreholes. Vertical seismic profiling is tested as a means to map the areal distribution of the plume. Low resolution but inexpensive streaming potential measurements are being carried out to sense the advancing CO_2 front. Hydrologic interference tests conducted prior to CO_2 injection provide information on the hydrologic properties of the target interval as well as information on hydrologic boundary conditions. Pressure transient measurements made during CO_2 injection provide additional information on the two phase flow conditions in the reservoir. Geochemical baseline samples are also collected prior to CO_2 injection. During CO_2 injection, the monitoring well is being sampled continuously at the surface and periodic samples are being taken with a bottom hole sampling device. Geochemical analyses include free and dissolved gas species (CO_2, CH_4, H_2S, and others), and fluid chemistry (major and minor caions and anions, pH,

alkalinity, TDS, and others). Candidate tracers include carbon and oxygen isotopes, PFTs, and noble gasses, which will provide additional information on fluid chemistry changes including dissolution of CO_2.